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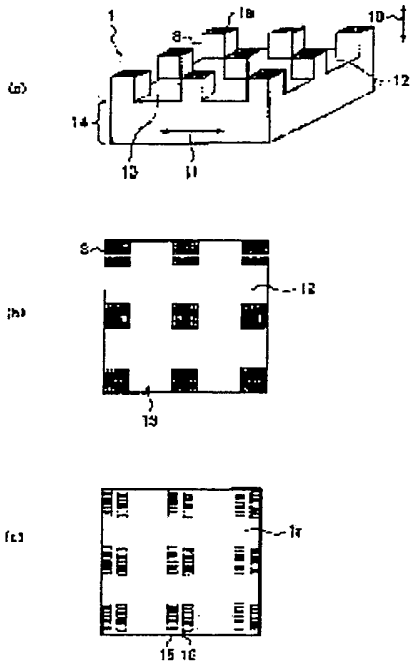
(54) PIEZOELECTRIC ACTUATOR AND FABRICATION THEREOF

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a compact piezoelectric actuator, and a fabrication method thereof, in which piezoelectric elements are formed at high positional accuracy and high integration density through a simplified fabrication process.
SOLUTION: A pie-zoelectric material green sheet applied with a plurality of common electrodes, a piezoelectric material green sheet applied with a plurality of signal applying electrodes, and a sheet applied with no electrode are employed. A group of alternate laminate composed of a plurality of sheets applied with common electrode and a plurality of sheets applied with signal applying electrode and a group of laminate composed of a plurality of sheets applied with no inner electrode are laminated alternately and fired. Subsequently, grid-like trenches 12, 13 are made in the displacement output face side to form checkered driving posts 8 thus realizing a compact piezoelectric actuator having high positional accuracy and high integration density. The common electrode and the signal applying electrode can be connected electrically with an external power supply on the back plane 1r of the output plane for each driving post.



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最終頁に続く

(54)【発明の名称】圧電アクチュエータおよびその製造方法

1

(57)【特許請求の範囲】

【請求項１】　基板と、該基板上にアレイ状に配列されており、夫々が圧電横効果によって圧電式駆動機構として機能する複数個の駆動柱と、前記駆動柱の夫々に対応して配設される外部共通電極及び外部信号印加電極とを備え、

前記各駆動柱は、少なくとも該駆動柱下部の基板部分と共通のグリーンシートによって一体に形成されたブロックから成り、該ブロックは、前記外部共通電極に共通に接続された共通電極層を有し圧電材料から成る複数枚のグリーンシートと、前記外部信号印加電極に接続された信号印加電極層を有し圧電材料から成る複数枚のグリーンシートとが交互に積層された積層体構造に形成され、前記共通電極層及び信号印加電極層の夫々が、各駆動柱内に収容される駆動柱電極部と、該駆動柱電極部と前記

2

外部共通電極又は外部信号印加電極との間を接続する電極取出し部とから構成され、前記共通電極又は信号印加電極のそれぞれの電極取り出し部は積層方向に重ならない位置で配設され、前記外部共通電極及び前記外部信号印加電極が、前記基板の下面に配設されていることを特徴とする圧電アクチュエータ。

【請求項２】　前記共通電極層及び前記信号印加電極層の各縁部が、前記各駆動柱の側面に露出する、請求項１に記載の圧電アクチュエータ。

【請求項３】　前記共通電極層及び前記信号印加電極層の各縁部が、前記各駆動柱の側面で覆われる、請求項１記載の圧電アクチュエータ。

【請求項４】　前記駆動柱と実質的に同じ形状の複数のダミー柱を前記基板上に有する、請求項１～３の何れかに記載の圧電アクチュエータ。

【請求項５】　前記駆動柱及び前記基板が平行四辺形であり、前記駆動柱は前記基板の各辺に平行に配列される、請求項１～４の何れかに記載の圧電アクチュエータ。

【請求項６】　前記基板は、前記ブロックの間に挿入される別のブロックを含み、該別のブロックは圧電材料から成るグリーンシートの積層体として構成される、請求項１～５の何れかに記載の圧電アクチュエータ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、圧電アクチュエータおよびその製造方法に関し、更に詳しくは、特にインクジェット方式記録装置に最適で、高い位置精度、高集積密度で形成され、安定して駆動させることが可能な圧電アクチュエータおよびその製造方法に関するものである。

【０００２】

【従来の技術】インクジェット式のプリンタ（以下、インクジェット記録装置と言う）では、インクを噴射するインクジェットヘッドに、圧電アクチュエータが用いられていることが多い。インクジェットヘッドに用いる従来の圧電アクチュエータは、例えば特開平８－１５６２７２号に記載されている。以下、特開平８－１５６２７２号を引用し、図面を参照して、従来の圧電アクチュエータを説明する。図１２（ａ）及び（ｂ）は、それぞれ、従来の圧電アクチュエータを製造する工程毎の斜視図である。従来の圧電アクチュエータ３６を製造するには、まず、基板１４上に形成した電極用パタン２６、２７に沿って、積層型の圧電素子プレート２８を接合する（図１２（ａ）参照）。次いで、圧電素子プレート２８と基板１４の表面部とに、圧電素子プレート２８の長手方向と直交する所定ピッチのスリット加工を施して、複数の積層型圧電素子（駆動柱）２９、３０からなる圧電素子列３１を形成し、電極用パタン２６、２７を各積層型圧電素子２９に対応する個別電極（信号印加電極）３３に分断する（図１２（ｂ）参照）。

【０００３】各圧電素子列３１の圧電素子２９、３０の両端面には、内部電極を１層おきに相互接続した端面電極（外部電極）を設ける。一方の端面の外部電極を基板１４上の内部電極である共通電極３２に、他方の端面電極を基板１４上の内部電極である個別電極３３に、それぞれ導電性材料を介して接続する。更に、基板１４上の圧電素子２９、３０の周囲に、上面高さが圧電素子２９、３０とほぼ同一になる支持部材３４を接合する。積層型圧電素子２９、３０は、変位出力面を基板と反対側の上端面に有し、圧電縦効果によって積層方向と同一方向の変位を出力する。

【０００４】

【発明が解決しようとする課題】ところで、従来技術では、圧電素子プレートに長手方向と直交する方向のスリットを加工することにより複数本の圧電素子を形成するため、各圧電素子の平面形状は長方形であり、それに対応して上方に配されるインク室やインク吐出用のノズルも同様の配置となる。また、圧電縦効果を利用して圧電素子を駆動させているため、圧電素子プレートの端面電極と電極パタンとを導電性材料によって接続する行程が必要となる。更に、基板上の圧電素子プレート長手方向と直交する方向の両端部には、各圧電素子列に対応する電極パタンとして個別電極を形成する。このため、１つのアクチュエータユニット上に圧電素子列を２列を超えて、言い換えると２列よりも多く設けることは困難であり、従って、単位面積あたりのノズル数を高めることができず、しかも、生産性が低いという第１の問題があった。また、基板と圧電素子との材質が異なるため、スリットを加工する際、互いの熱膨張係数や加工性の差が生じる第２の問題があった。更に、圧電素子プレート及び支持部材を基板に接合させる際、何れも接着する行程が必要であり、また、圧電素子プレートを接着する際に基板上の電極パタンに位置合わせしたとき、各圧電素子プレート間の相対的な位置がずれるという第３の問題もあった。以上のような事情に照らして、本発明の目的は、圧電素子が簡略化された製造工程で高い位置精度及び高集積密度で形成された、コンパクトな圧電アクチュエータ及びその製造方法を提供することである。

【０００５】

【課題を解決するための手段】本発明者は、鋭意検討の結果、変位出力面が圧電横効果を利用して変位する圧電アクチュエータを考え、圧電素子を縦横両方向に略等間隔な碁盤目状又は千鳥状に平面配置することで、圧電素子を高集積に配置できることを見い出し、本発明者は本発明を完成するに至った。

【０００６】上記目的を達成するために、本発明の圧電アクチュエータは、基板と、該基板上にアレイ状に配列されており、夫々が圧電横効果によって圧電式駆動機構として機能する複数個の駆動柱と、前記駆動柱の夫々に対応して配設される外部共通電極及び外部信号印加電極とを備え、前記各駆動柱は、少なくとも該駆動柱下部の基板部分と共通のグリーンシートによって一体に形成されたブロックから成り、該ブロックは、前記外部共通電極に共通に接続された共通電極層を有し圧電材料から成る複数枚のグリーンシートと、前記外部信号印加電極に接続された信号印加電極層を有し圧電材料から成る複数枚のグリーンシートとが交互に積層された積層体構造に形成されることを特徴とする。

【０００７】本発明の圧電アクチュエータによれば、駆動柱と基板とを共通のグリーンシートによって一体に形成したことにより、駆動柱の位置精度の向上が可能となり、また、製造する際の工程数が削減できる。ここで、前記外部共通電極及び前記外部信号印加電極は、前記基板の下面に配設することが出来る。また、前記共通電極

層及び前記信号印加電極層の各縁部が、前記各駆動柱の側面に露出することも、前記各駆動柱の側面で覆われるとすることも出来る。

【０００８】前記共通電極層及び信号印加電極層の夫々を、各駆動柱内に収容される駆動柱電極部と、該駆動柱電極部と前記外部電極との間を接続する電極取出し部とから構成することが好ましい。この場合、外部電極との接続が容易である。また、前記駆動柱と実質的に同じ形状の複数のダミー柱を前記基板上に有することも本発明の好ましい態様である。或いは、前記駆動柱及び前記基板を平行四辺形として形成し、例えば平行四辺形の辺の成す角度を４５～９０°とすることが出来る。前記駆動柱の下部以外の基板部分を圧電材料から成るグリーンシートの積層体から成る別のブロックとして構成することも本発明の好ましい態様である。この場合、製造が容易となる。

【０００９】外部共通電極及び外部信号印加電極は、一般に外部電源に接続される。例えば、内部電極である共通電極層及び信号印加電極層は、通常、駆動柱を構成する駆動柱部と、駆動柱部に接続し、裏面にまで到達する電極取り出し部とから構成され、共通電極層及び信号印加電極層の形状は、駆動柱部では同一形状で、かつ積層方向について同一位置に配置され、電極取り出し部では、積層方向について互いに重ならないように配置される。従って、各駆動柱毎に、共通電極の電極取り出し部、及び、信号印加電極の電極取り出し部の端部を裏面にそれぞれ配列して露出させ、各外部電極に容易に接続できる。また、グリーンシートの表面に電極ペーストを塗布して外部電極を形成するにあたり、電極層の駆動柱部が駆動柱の内部に収まるように予め形成してもよい。そして、駆動柱を形成する際、内部電極が駆動柱内に収まるように格子状の溝を加工することで、耐久性に優れた圧電アクチュエータが製作される。

【００１０】駆動柱に加えて電極層を有しないダミー柱を形成すると、駆動柱を個別に駆動させて、駆動する駆動柱（以下、駆動駆動柱と言う）の隣の駆動柱を駆動させないときに、駆動させない駆動柱が変位することを大きく抑制でき、駆動駆動柱の出力変位を有効利用できる。

【００１１】本発明の圧電アクチュエータは、好適には、インクジェットヘッド用の圧電アクチュエータとして利用される。この場合、各駆動柱はインクジェットヘッドのインクノズルからインクを流出させる駆動機構として機能する。これにより、高密度に印字可能なインクジェット記録装置用の圧電アクチュエータを実現できる。

【００１２】また、本発明の圧電アクチュエータの製造方法は：圧電材料から成り、共通電極層を有する複数の第１のグリーンシートを形成するステップ；圧電材料から成り、信号印加電極層を有する複数の第２のグリーンシートを形成するステップ；圧電材料から成る少なくとも１つの第３のグリーンシートを形成するステップ；夫々が第１のグリーンシート及び第２のグリーンシートを交互に含む複数の第１のブロックと、複数の第３のグリーンシートから成る少なくとも１つの第２のブロックとを交互に積層して積層体を形成するステップ；前記積層体の積層方向に延びる第１の溝と、前記積層方向に直交する方向に延びる第２の溝とを積層体の表面に形成して、アレイ状に配設された複数の駆動柱を形成するステップ；及び、前記各駆動柱の共通電極層を共通に接続する外部共通電極及び前記各駆動柱の信号印加電極層を接続する外部信号印加電極を、前記各駆動柱に対応して形成するステップを有することを特徴とする。

【００１３】本発明方法によれば、前記本発明の圧電アクチュエータを生産性高く製造できる。積層体を形成する際には、プレス等により加圧を行い、また、焼結を利用することが好ましい。焼結としては、例えば焼成を行う。その際、圧電材料グリーンシートがバインダを含有する場合、脱バインダ工程を行う。また、加工は、通常、研削により行う。溝は、格子状なので概略等ピッチに形成される。溝の形成により、碁盤目状に平面配置された高集積密度の駆動柱を形成できる。また、基板を平行四辺形とし、溝を平行四辺形の辺に沿って形成してもよい。平行四辺形の隣接する辺の成す角度は、例えば４５～９０°程度とする。

【００１４】

【発明の実施の形態】以下に、実施形態例を挙げ、添付図面を参照して、本発明の実施の形態を具体的かつより詳細に説明する。

実施形態例１

本実施形態例は、第１発明の実施形態例である。図１（ａ）から（ｃ）は、それぞれ、本実施形態例の圧電アクチュエータの斜視図、平面図、及び、背面図である。

【００１５】本実施形態例の圧電アクチュエータ１は、それぞれ、格子状の溝により区分された各区画に配置され、かつ、圧電式駆動機構として機能する複数個の駆動柱８を備えている。図２は、圧電材料グリーンシートとその上に塗布した内部電極である共通電極のパタンを示す平面図、図３は、圧電材料グリーンシートとその上に塗布した内部電極である信号印加電極のパタンを示す平面図である。駆動柱８は、圧電材料グリーンシートを介して溝の幅方向に交互に積層された共通電極２及び信号印加電極３の積層電極構造からなり、圧電横効果により駆動柱高さ方向の外部に変位出力する変位出力面（圧電アクチュエータ出力面）１ａを駆動柱上端面に有する。共通電極２及び信号印加電極３は、何れも、駆動柱を構成する駆動柱部６と、駆動柱部６に接続し、圧電アクチュエータ１の裏面１ｒ（図１（ｃ）参照）にまで到達する電極取り出し部７とから構成される。また、共通電極２及び信号印加電極３は、駆動柱部６が積層方向につい

て同一位置で、また、電極取り出し部７が積層方向について互いに重ならない位置にそれぞれ配置されるように設けられている。裏面１ｒでは、各駆動柱毎に、共通電極の電極取り出し部、及び、信号印加電極の電極取り出し部の端部が、それぞれ一列に配列して露出している（図１（ｃ）参照）。

【００１６】本実施形態例では、各シートに塗布する共通電極２及び信号印加電極３はそれぞれ３つであるが、駆動柱８の所望数に応じて更に多くしてもよい。また、圧電材料グリーンシート（以下、単にグリーンシートと言う）として圧電材料であるジルコン酸チタン酸鉛系セラミックスと有機バインダからなるものを用いたが、圧電材料としては一般的な強誘電体等を用いてもよい。また、グリーンシートはドクターブレード法を用いて製作し、厚さは３０μｍ程度としたが、圧電アクチュエータ１の所望の変位量に応じた厚さとすることが可能である。

【００１７】以下、圧電アクチュエータの製造方法を説明する。まず、共通電極２を塗布したシート４と信号印加電極３を塗布したシート５とを、それぞれの電極パタンの駆動柱部６が互いに重なるように、かつ、電極取り出し部７が共通電極２と信号印加電極３とで互いに重ならないように、交互に積層した（以下、この積層したものを「駆動柱部を含む層群」と言う）。駆動柱部を含む層群は２０層からなる。また、電極を塗布しないシートを別途に複数枚積層した（以下、この積層したものを「駆動柱部を含まない層群」と言う）。駆動柱部を含まない層群も２０層からなる。尚、グリーンシート上の共通電極２及び信号印加電極３は、銀パラジウムペーストを塗布（スクリーン印刷）することにより形成したが、その他の導体金属を用いて蒸着等により形成してもよい。

【００１８】次いで、駆動柱部を含む層群１ｃと駆動柱部を含まない層群１ｄとを更に交互に積層し、駆動柱部を含む層群１ｃを３体、駆動柱部を含まない層群１ｄを２体有する積層体１ｅを形成した。図４（ａ）及び（ｂ）は、それぞれ、積層体１ｅの斜視図及び平面図である。図４で破線は、内蔵されている共通電極２及び信号印加電極３の外枠を示す。尚、図４（ａ）では、簡単のため、駆動柱部を含む層群１ｃのうち最も手前のもののにのみ破線を描いている。交互に積層した結果、図４（ａ）及び（ｂ）に示すように、駆動柱８を形成する部分が、内部電極２、３の列設方向１１すなわち各グリーンシートに平行な方向に、及び、列設方向１１に直交する方向に、それぞれ３列に配列された。尚、駆動柱８の所望の配列に応じて、さらに多くの層群を積層することも可能である。

【００１９】次いで、熱プレス等によって上記の積層体１ｅを圧着、一体化した。積層体１ｅの内部には多量の有機バインダが含まれているため、更に、脱バインダ行程を行い、続いて１１００℃で焼成を行った。次いで、焼成後の積層体に、ダイシングソーにより圧電アクチュエータのユニットとしての所望の寸法に切断した。その際、各駆動柱８を分離、独立させるための溝加工時に積層体を位置決めする必要があることを考慮し、共通電極２及び信号印加電極３の端部が変位出力面１ａに露出するように加工した。さらに、積層体の裏面側から、電極取り出し部７の端部が露出するような外形加工を行い、各駆動柱８に電圧を印加する端子を裏面１ｒに形成した。

【００２０】続いて、以下に説明するように、ダイシングソーによって溝加工を行って、駆動柱部６を有する駆動柱８を形成した。まず、列設方向１１で駆動柱部を含む層群間に、駆動柱部を含まない層群１ｄと同一の幅を有する複数本の溝１２を形成した。溝１２は、深さ１ｍｍの切り込みを上面から入れることにより形成した。続いて、溝１２と直交する内部電極積層方向に、駆動柱部同士間の間隔と同一幅を有する溝１３を加工し、複数本の駆動柱８を形成した（図１（ａ）及び（ｂ）参照）。

【００２１】以上の行程により、駆動柱８が圧電アクチュエータ１と同材料でかつ一体で構成され、駆動柱８がマトリクス状に平面配置された圧電アクチュエータが製作された。尚、溝１２及び１３の幅は何れも0.718ｍｍ、駆動柱８の縦横の幅は何れも0.3ｍｍであり、また、内部電極２、３の列設方向１１及びそれに直交する方向の各駆動柱ピッチは何れも1.018ｍｍであるが、これらの値は、駆動柱の所望ピッチ等に応じて変更することができる。

【００２２】次いで、各駆動柱８に印加電圧を加えるための外部電極接続を以下のようにして行った。裏面１ｒでは、各駆動柱８に対応した共通電極２の取り出し部断面１５と信号印加電極３の取り出し部断面１６とがそれぞれ露出しており、これらに銀ペースト（図示せず）を塗布して外部電極を形成した。更に、外部電極に、各駆動柱８の共通電極２と信号印加電極３の間に選択的に電圧印加することの可能なパタンを有するＦＰＣケーブル（図示せず）を接続した。この結果、各駆動柱８を個別に駆動することができる。なお、外部電極は、上記の方法に代えて、導体金属の蒸着や導体ペーストの印刷などを行って形成してもよい。

【００２３】以下、本実施形態例で製作した圧電アクチュエータ１の動作について説明する。裏面１ｒに接続したＦＰＣケーブルを介して、各駆動柱８の共通電極２と信号印加電極３との間に電圧を印加する。これにより、電極取り出し部７を介して共通電極２の駆動柱部６と信号印加電極３の駆動柱部６との間に電位差が生じ、圧電横効果によって、変位出力面１ａに、垂直方向１０の変位が出力される。

【００２４】尚、圧電アクチュエータ１が、共通電極２及び信号印加電極３に代えて、圧電材料グリーンシート

を介して溝の深さ方向に交互に積層された共通電極及び信号印加電極を備え、圧電縦効果により駆動柱高さ方向の外部に変位出力する変位出力面（圧電アクチュエータ出力面）を駆動柱上端面に有する構造であっても、本実施形態例と同様、コンパクトであって各駆動柱毎に変位させることが可能である。

【００２５】圧電アクチュエータの動作確認を行った実験例１

圧電アクチュエータ１に接続されたＦＰＣケーブルに、図１０に示すような波形の電圧を印加した結果、最大0.3μｍ程度の変位を出力できた。その他の駆動柱に対しても同様の駆動実験を行った結果、すべての駆動柱で同等の出力変位特性が得られた。さらに、図１１に示すように、ノズル２１、圧力室２２、インク流路２３、振動板２４を有するインクジェットヘッドに圧電アクチュエータ１を組み込むことにより取り付けた。次いで、図１０に示した波形の電圧を印加してインク滴の吐出評価試験を行った結果、すべてのノズル２１からインク滴が安定的に吐出できることを確認した。

【００２６】実施形態例２

本実施形態例は、第２発明の圧電アクチュエータ及びその製造方法の実施形態例である。図５は、本実施形態例の圧電アクチュエータの平面図である。本実施形態例の圧電アクチュエータ４０は、縦横に直交するマトリクス状に平面配置されている実施形態例１の圧電アクチュエータ１に比べ、駆動柱が千鳥状に平面配置されていることを除いて、圧電アクチュエータ１と同じ構成である。圧電アクチュエータ４０の駆動柱４２は、それぞれ、交差角度θ＝８５°で互いに交差する略格子状の溝により区分された各区画に千鳥状に配置され、かつ、圧電式駆動機構として機能する。

【００２７】本実施形態例で圧電アクチュエータ４０を製作するには、実施形態例１で使用したシート４及びシート５を用い、実施形態例１に比べ、駆動柱部を含む層群と駆動柱部を含まない層群とを交互に積層する際、駆動柱部を含む層群１ｃが列設方向１１に同一所定長さだけ順次移動した状態にして積層した。所定長さとは、交差角度θに対応する長さである。その後、実施形態例１と同様、脱バインダ行程、焼成及び外形加工を行った。

【００２８】続いて、ダイシングソーによって、以下に説明する溝加工を行い、上面に露出した内部電極（共通電極２及び信号印加電極３）の駆動柱部６を含む駆動柱４２を形成した。まず、実施形態例１と同様に溝１２を形成した。次いで、溝１２と８５°で交差する溝４３を形成した。以上の行程により、駆動柱４２が、圧電アクチュエータ４０と一体でかつ同じ材料で構成され、しかも千鳥状に平面配置された圧電アクチュエータ４０が製作された。

【００２９】圧電アクチュエータの動作確認を行った実験例２

実験例１と同様の駆動実験を行った結果、すべての駆動柱が0.3μｍ程度の変位を出力することを確認した。さらに、本実施形態例で製作したアクチュエータを図１１に示したインクジェットヘッドに組み込んで吐出評価試験を行ったところ、全てのノズル２１からインク滴を安定して吐出できた。

【００３０】実施形態例３

本実施形態例は、外部電源の内部電極への電気接続を、アクチュエータ出力面の裏面１ｒではなく変位出力面１ａで行うことが可能な圧電アクチュエータ及びその製造方法の実施形態例である。図６（ａ）及び（ｂ）は、何れも本実施形態例の圧電アクチュエータ４４の内部電極パタンを示す側面断面図であり、図６（ａ）は共通電極パタンを示し、図６（ｂ）は信号印加電極パタンを示す。圧電アクチュエータ４４は駆動柱４８を備えている。駆動柱４８は、互いに対向する側面４６ａ、ｂにそれぞれ共通電極２及び信号印加電極３の端部が露出してることを除いて、駆動柱８と同じ構成で同じ位置に設けられている。

【００３１】圧電アクチュエータ４４を製作するには、実施形態例１又は２で、グリーンシート上に共通電極２、信号印加電極３を塗布する代わりに、駆動柱部４７ａ、ｂをそれぞれ有する共通電極及び信号印加電極を塗布（スクリーン印刷）することにより形成した。その後、実施形態例１又は２と同様、積層体を形成し、外形加工及び溝加工を行うことにより、相互に対向する側面４６ａ、ｂに、それぞれ、共通電極の駆動柱部４７ａ及び信号印加電極の駆動柱部４７ｂの端部をそれぞれ露出した駆動柱４８を形成した。更に、側面４６ａ、ｂに外部電極として銀ペースト（図示せず）を全面に塗布し、続いて、外部電源から電圧を印加する電気配線をこの外部電極に接続した。

【００３２】本実施形態例の圧電アクチュエータ４４は、実施形態例１及び２のように、駆動柱部６からアクチュエータ出力面の裏面１ｒへ接続する電極取り出し部７を形成しなくてもよいので、内部電極材や圧電材料の使用量を低減でき、製造コストの低い圧電アクチュエータが実現される。

【００３３】実施形態例４

図７は、本実施形態例の圧電アクチュエータの斜視図である。本実施形態例の圧電アクチュエータ５０は、格子状の溝加工によって積層体上部に駆動柱のみが形成される実施形態例１の圧電アクチュエータに比べ、駆動柱間に、駆動柱と概略同一寸法で、積層された圧電材料グリーンシートのみからなる支持柱５２をダミー柱として有する。支持柱５２は、内部電極である共通電極２及び信号印加電極３を有さず、積層された圧電材料グリーンシートのみから構成される。

【００３４】圧電アクチュエータ５０の製造方法を以下に説明する。本実施形態例では、まず、実施形態例１と

同様にして積層体１ｅを形成した。次いで、駆動柱８及び支持柱５２を形成する溝であって、列設方向１１に平行で、駆動柱部を含む層群１ｃと駆動柱部を含まない層群１ｄとの間に形成された溝５６を加工した。続いて、溝５６に直交する方向で駆動柱８と支持柱５２との間に溝５８を加工した。本実施形態例では、駆動柱８及び支持柱５２の幅を0.3ｍｍ、溝５６、５８の幅を0.209ｍｍ、駆動柱８のピッチを内部電極の列設方向１１及び列設方向に直交する方向にそれぞれ1.018ｍｍとしたが、これらの値は、駆動柱の所望ピッチ等に応じて変更することができる。

【００３５】圧電アクチュエータの動作確認を行った実験例３

本実施形態例により製造された圧電アクチュエータ５０を実験例１と同様、インクジェットヘッドとして適用し、支持柱５２がある場合と無い場合とでのインク滴の吐出について比較する実験を行った。その結果、支持柱５２を更に備えたことにより他の部位の変形が抑制され、駆動柱８の出力変位を有効利用でき、クロストーク現象の度合いを低減できた。すなわち、吐出に要する出力変位を軽減でき、また、各ノズルの吐出特性のばらつきが軽減することが確認された。

【００３６】実施形態例５

本実施形態例は、実施形態例１に比べ、内部電極の駆動柱部が露出しない構造の圧電アクチュエータの実施形態例である。図８（ａ）及び（ｂ）は、何れも本実施形態例の圧電アクチュエータ６０の内部電極パタンを示す側面断面図であり、図８（ａ）は共通電極パタンを示し、図８（ｂ）は信号印加電極パタンを示す。圧電アクチュエータ６０は、内部電極である共通電極及び信号印加電極が、圧電アクチュエータ６０の駆動柱６２に内蔵されて圧電材料グリーンシート材によって表面が覆われていることを除いて、実施形態例１の圧電アクチュエータ１と同じである。

【００３７】圧電アクチュエータ６０を製造するには、溝を加工する際、内部電極の駆動柱部６６の端部が駆動柱６２の外側に露出しないように加工することを除いて、実施形態例１と同じである。

【００３８】本実施形態例では、グリーンシート上に内部電極を塗布する工程で、駆動柱部６６を駆動柱６２の内部に収まるように形成し、内部電極が駆動柱６２の外側に露出しないため、各電極層間の短絡を抑制できる効果がある。

【００３９】圧電アクチュエータの性能確認を行った実験例

圧電アクチュエータ６０を用い、内部電極の駆動柱部６６が露出した場合と露出しない場合の耐久性能を比較する実験を行った。その結果、駆動柱部６６を露出させないことによって耐久性を向上できることが確認された。

【００４０】実施形態例５の改変例

実施形態例５では、格子状又は略格子状の溝の深さは、図８に示したように、内部電極の駆動柱部６６の下端に合わせて加工したが、本改変例の第１圧電アクチュエータ（図示せず）は、格子状の溝を駆動柱部６６の下端よりも相対的に深く形成してなる圧電アクチュエータである。第１圧電アクチュエータでは、溝底エッジ部周辺での応力集中が緩和され、圧電アクチュエータ６０の耐久性を更に向上できる効果が得られた。また、本改変例の第２圧電アクチュエータ（図示せず）は、駆動柱部６６の下端位置が格子状溝の底より深い圧電アクチュエータである。第２圧電アクチュエータでは、同一高さの駆動柱と比較して出力変位を向上できる効果が得られた。更に、実施形態例５では、駆動柱を縦横３×３の９個を平面配置する構成としたが、所望の配列に応じ、１枚のシートの電極パタン数を増加したり、駆動柱部を含む層群と駆動柱部を含まない層群との積層数を増加したりすることにより、圧電アクチュエータ６０に比べて更に多くの駆動柱６２を有する圧電アクチュエータを形成することができた。尚、本改変例と同様の効果が実施形態例１から４でも得られることを確認した。

【００４１】実施形態例６

図９（ａ）及び（ｂ）は、何れも本実施形態例の圧電アクチュエータの内部電極パタンを示す側面断面図であり、図９（ａ）は共通電極パタンを示し、図９（ｂ）は信号印加電極パタンを示す。本実施形態例の圧電アクチュエータ７０は、内部電極が、電極取り出し部７６ａ、ｂを電極取り出し部７に代えて有することを除いて、実施形態例５の圧電アクチュエータ６０と同じ構成である。電極取り出し部７６ａ、ｂは、圧電アクチュエータ７０の駆動柱７２の対向する側面７４ａ、ｂに端部を露出している。本実施形態例では、圧電アクチュエータ７０を製造した後、側面７４ａ、ｂに露出した内部電極端部に銀ペーストを塗布してなる外部電極７８ａ、ｂを形成した。本実施形態例により、実施形態例５と同様の効果を奏することができた。

【００４２】

【発明の効果】以上説明したように、本発明の第１発明に係る圧電アクチュエータによれば、それぞれ、格子状の溝により区分された各区画に配置され、かつ、圧電式駆動機構として機能する複数個の駆動柱を備え、圧電横効果により駆動柱高さ方向の外部に変位出力する。これにより、複数の駆動柱を圧電アクチュエータと同じ材質で、かつ圧電アクチュエータと一体に設けることができるので、駆動柱の位置精度の向上及び製造工程の削減が可能となる。また、駆動柱をマトリクス状に平面配置でき、かつ駆動柱を構成する内部電極の電気的な接続端部をアクチュエータ裏面で行えるため、駆動柱が高集積密度で配置されたコンパクトな圧電アクチュエータが実現される。第２、第３発明でも同様の効果を奏することができる。好適には、駆動柱間に、駆動柱と概略同一高さ

で、積層された圧電材料グリーンシートのみからなるダミー柱を設ける。これにより、クロストーク現象を低減できる。

【図面の簡単な説明】

【図１】図１（ａ）から（ｃ）は、それぞれ、実施形態例１の圧電アクチュエータの斜視図、平面図、及び、背面図である。

【図２】圧電材料グリーンシートとその上に塗布した内部電極である共通電極のパタンを示す平面図である。

【図３】圧電材料グリーンシートとその上に塗布した内部電極である信号印加電極のパタンを示す平面図である。

【図４】図４（ａ）及び（ｂ）は、それぞれ、実施形態例１で形成される積層体の斜視図及び平面図である。

【図５】実施形態例２の圧電アクチュエータの平面図である。

【図６】図６（ａ）及び（ｂ）は、実施形態例３の圧電アクチュエータの内部電極の駆動柱部パタンを示す側面断面図であり、図６（ａ）は共通電極、図６（ｂ）は信号印加電極の駆動柱部を示す。

【図７】実施形態例４の圧電アクチュエータの斜視図である。

【図８】図８（ａ）及び（ｂ）は、何れも実施形態例５の圧電アクチュエータの内部電極パタンを示す側面断面図であり、図８（ａ）は共通電極パタンを示し、図８（ｂ）は信号印加電極パタンを示す。

【図９】図９（ａ）及び（ｂ）は、何れも実施形態例６の圧電アクチュエータの内部電極パタンを示す側面断面図であり、図９（ａ）は共通電極パタンを示し、図９（ｂ）は信号印加電極パタンを示す。

【図１０】実施形態例１から６で、共通電極と信号印加電圧との間に印可する電圧の波形である。

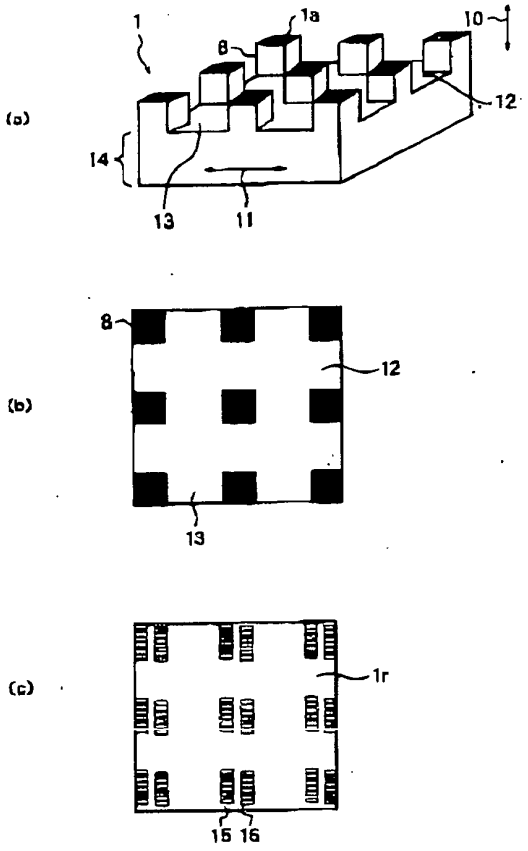
【図１１】実施形態例１の圧電アクチュエータをインクジェットヘッドに組み込んだ状態を示す側面断面図である。

【図１２】図１２（ａ）及び（ｂ）は、それぞれ、従来の圧電アクチュエータを製造する工程毎の斜視図である。

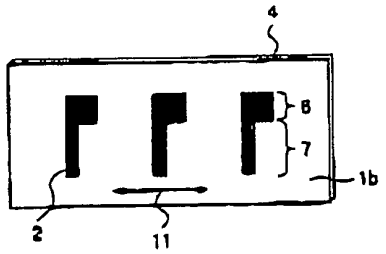
【符号の説明】

１　圧電アクチュエータ
１ａ　変位出力面
１ｃ　駆動柱部を含む層群
１ｄ　駆動柱部を含まない層群
１ｅ　積層体
１ｒ　裏面
２　共通電極
３　信号印加電極
４　共通電極を塗布したグリーンシート（シート）
５　信号印加電極を塗布したグリーンシート（シート）
６　駆動柱部
７　電極取り出し部
８　駆動柱
１０　垂直方向
１１　列設方向
１２　溝
１３　溝
１４　基板
１５　共通電極の取り出し部断面
１６　信号印加電極の取り出し部断面
２１　ノズル
２２　圧力室
２３　インク流路
２４　振動板
２６　電極用パタン
２７　電極用パタン
２８　圧電素子プレート
２９　駆動部圧電素子
３０　固定部圧電素子
３１　圧電素子列
３２　共通電極
３３　個別電極
３４　支持部材
３６　圧電アクチュエータ
４０　圧電アクチュエータ
４２　駆動柱
４３　溝
４４　圧電アクチュエータ
４６ａ、ｂ　側面
４７ａ、ｂ　駆動柱部
４８　駆動柱
５０　圧電アクチュエータ
５２　支持柱
５６　溝
５８　溝
６０　圧電アクチュエータ
６２　駆動柱
６６　駆動柱部
７０　圧電アクチュエータ
７２　駆動柱
７４ａ、ｂ　側面
７６ａ、ｂ　電極取り出し部
７８ａ、ｂ　外部電極

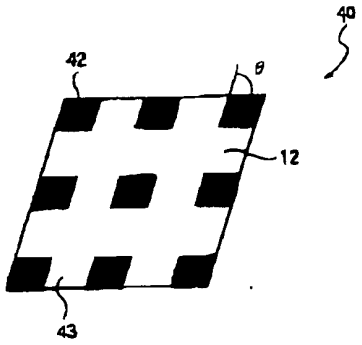
【図１】



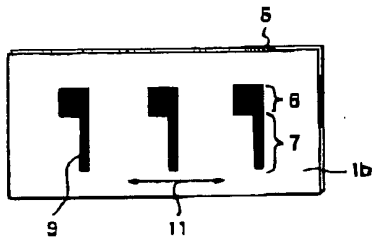
【図２】



【図５】



【図３】



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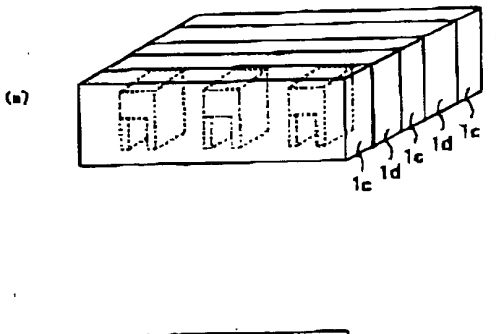
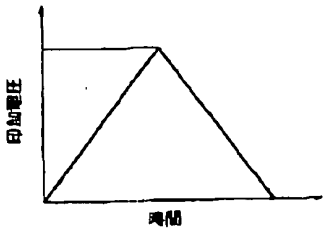
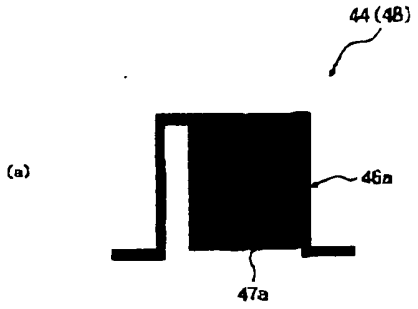


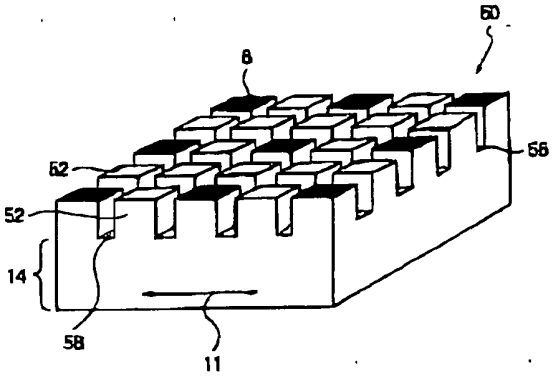
【図１０】



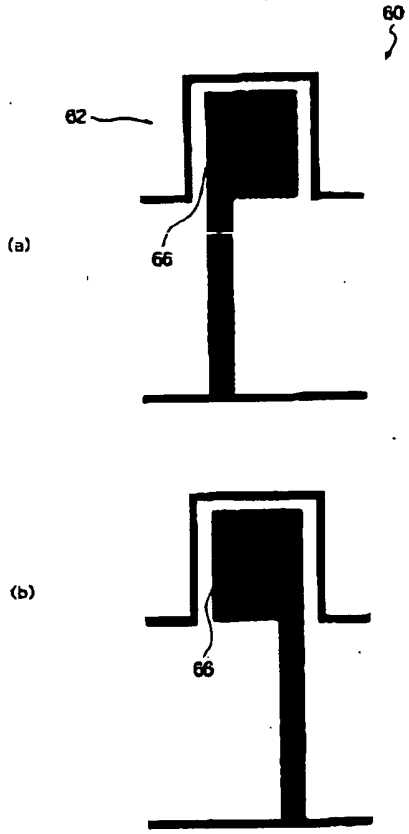
【図６】


44 (48)
(a)
46a
47a
(b)
46b
47b

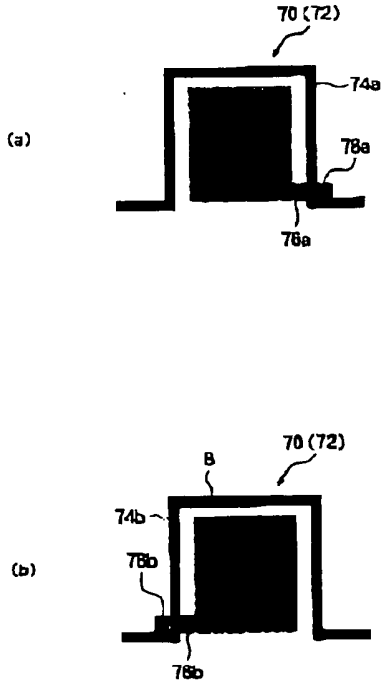
【図７】


50
8
56
52
52
14
58
11

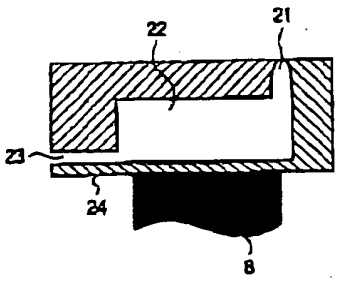
【図８】


60
62
(a)
66
(b)
66

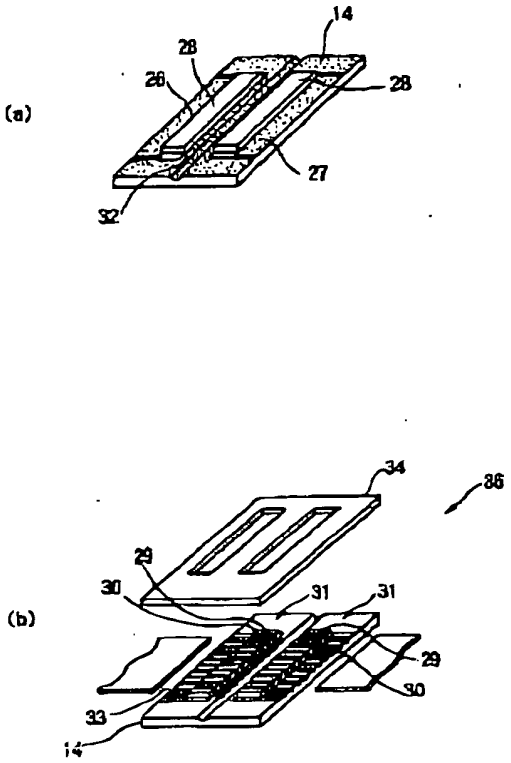
【図９】


70 (72)
74a
(a)
78a
76a
70 (72)
8
74b
(b)
78b
76b

【図１１】



【図１２】



フロントページの続き

(56)参考文献　特開　平３－266644（ＪＰ，Ａ）
特開　平８－80614（ＪＰ，Ａ）
特開　平８－174818（ＪＰ，Ａ）
特開　平８－52873（ＪＰ，Ａ）
特開　平３－243358（ＪＰ，Ａ）
特開　平７－166383（ＪＰ，Ａ）
特開　平７－117228（ＪＰ，Ａ）
特開　平８－25622（ＪＰ，Ａ）
特開　平８－192514（ＪＰ，Ａ）

(58)調査した分野(Int.Cl.', ＤＢ名)
B41J　2/045
B41J　2/055

JAPANESE [JP,11-227189,A]

AA

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS

Translation done.]

* NOTICES *

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CLAIMS

[Claim(s)]
[Claim 1] It has two or more drive pillars which are arranged at each partition classified by the grid-like slot, respectively, and function as a piezo-electric formula drive. The electrostrictive actuator characterized by having the displacement output screen which a drive pillar consists of laminating electrode structure of the common electrode layer by which the laminating was carried out crosswise [of a slot] by turns through the piezoelectric-material green sheet, and a signal impression electrode layer, and carries out a displacement output to the exterior of the drive pillar height direction by the piezo-electric transversal effect in a drive pillar upper-limit side.
[Claim 2] It is arranged alternately at each partition classified by the slot of the shape of an abbreviation grid which crosses mutually at an angle of within the limits of 45 degrees or more 90 degrees or less, respectively. It has two or more drive pillars which function as a piezo-electric formula drive. and a drive pillar The electrostrictive actuator characterized by having the displacement output screen which consists of laminating electrode structure of the common electrode layer by which the laminating was carried out crosswise [of a slot] by turns through the piezoelectric-material green sheet, and a signal impression electrode layer, and carries out a displacement output to the exterior of the drive pillar height direction by the piezo-electric transversal effect in a drive pillar upper-limit side.
[Claim 3] The electrostrictive actuator according to claim 1 or 2 characterized by having the electrode takeoff connection which has the edge exposed to the rear face which connects with a common electrode and a signal impression electrode, respectively, and counters the displacement output screen of a drive pillar, respectively.
[Claim 4] The electrostrictive actuator characterized by to have the displacement output screen which it has two or more drive pillars which are arranged on a substrate through a slot and function as a piezo-electric formula drive, respectively, and a drive pillar consists of laminating electrode structure of the common electrode layer by which the laminating was carried out by turns in the direction of the depth of flute through the piezoelectric-material green sheet, and a signal impression electrode layer, and carries out a displacement output outside by the piezo-electric longitudinal effect in the drive pillar upper-limit side of a substrate and an opposite side.
[Claim 5] An electrostrictive actuator given in any 1 term of the claims 1-4 characterized by having a drive pillar and the dummy pillar of outline same height in drive intercolumniation.
[Claim 6] A common electrode and a signal impression electrode are an electrostrictive actuator given in any 1 term of the claims 1-5 characterized by being built in a drive pillar and the front face being worn by piezoelectric-material green-sheet material.
[Claim 7] It is an electrostrictive actuator given in any 1 term of the claims 1-6 which an electrostrictive actuator is an electrostrictive actuator for ink-jet heads, and are characterized by each drive pillar functioning as a drive into which ink is made to flow out of the ink nozzle of an ink-jet head.
[Claim 8] The manufacture method of an electrostrictive actuator according to claim 1 characterized by providing the following The process which applies the electrode paste of a predetermined configuration to the predetermined position of one field of a piezoelectric-material green sheet, forms a common electrode or a signal impression electrode, and forms the laminating electrode soma material which has the internal electrode which comes by turns to carry out two or more sheet laminating of the piezoelectric-material green sheet which subsequently has the piezoelectric-material green sheet which has a common electrode, and a signal impression electrode, and the process which forms the laminating electrode soma material which does not have the internal electrode which comes to carry out two or more sheet laminating of the piezoelectric-material green sheet Subsequently, the process which carries out the laminating of the laminating electrode soma material which has an internal electrode, and the laminating electrode soma material which does not have an internal electrode by turns, pressurizes it, sinters further, and forms a laminating electrode object Subsequently, the process which forms the field which processes the displacement output-screen side which intersects perpendicularly with a sheet side, and has a displacement output screen Furthermore, the process which forms a grid-

like slot in the field which has a displacement output screen, and forms the drive pillar by which plane configuration was carried out to the shape of the squares of outline regular intervals

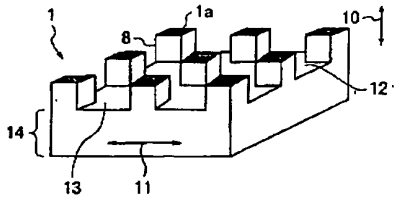
[Claim 9] The manufacture method of an electrostrictive actuator according to claim 2 characterized by providing the following the process which applies the electrode paste of a predetermined configuration to the predetermined position of one field of a piezoelectric-material green sheet, forms a common electrode or a signal impression electrode, and forms the laminating electrode soma material which has the internal electrode which comes by turns to carry out two or more sheet laminating of the green sheet which subsequently has the green sheet which has a common electrode, and a signal impression electrode, and a piezoelectric-material green sheet -- two or more sheets -- ****** -- the process which forms the laminating electrode soma material which does not have an internal electrode Subsequently, the laminating electrode object formation process which forms the laminating electrode object which shifts in predetermined length one by one, carries out the laminating of the laminating electrode soma material which has an internal electrode, and the laminating electrode soma material which does not have an internal electrode by turns, and pressurizes it, and it comes to sinter further Subsequently, the process which forms the field which processes the displacement output-screen side which intersects perpendicularly with a sheet side, and has a displacement output screen Furthermore, the process which forms the slot of the shape of an abbreviation grid which has the degree of crossed axes angle corresponding to the length shifted at the laminating electrode object formation process in the field which has a displacement output screen

[Claim 10] The manufacture method of the electrostrictive actuator according to claim 9 characterized by the degree of crossed axes angle of a slot being within the limits of 45 to 90 degrees.

[Translation done.]

Drawing selection [Representative drawing]

a)



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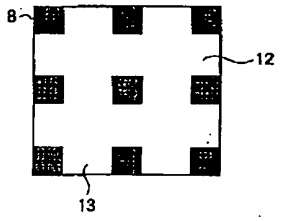

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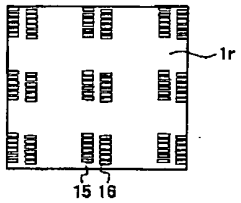

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] About an electrostrictive actuator and its manufacture method, especially in more detail, this invention is the the best for an ink-jet method recording device, is formed by high position precision and high accumulation density, and relates to an electrostrictive actuator with possible making it stabilize and drive, and its manufacture method.
[0002]
[Description of the Prior Art] By the printer (henceforth an ink-jet recording device) of an ink-jet formula, the electrostrictive actuator is used for the ink-jet head which injects ink in many cases. The conventional electrostrictive actuator used for an ink-jet head is indicated by JP,8-156272,A. Hereafter, JP,8-156272,A is quoted and the conventional electrostrictive actuator is explained with reference to a drawing. Drawing 12 (a) and (b) are the perspective diagrams for every process which manufactures the conventional electrostrictive actuator, respectively. In order to manufacture the conventional electrostrictive actuator 36, along with the patterns 26 and 27 for electrodes formed on the substrate 14, the laminating type piezoelectric-device plate 28 is joined first (refer to drawing 12 (a)). Subsequently, slit processing of the predetermined pitch which intersects perpendicularly with the longitudinal direction of the piezoelectric-device plate 28 is given to the piezoelectric-device plate 28 and the surface section of a substrate 14, the piezoelectric-device train 31 which consists of two or more laminating type piezoelectric devices (drive pillar) 29 and 30 is formed, and the patterns 26 and 27 for electrodes are divided to the individual electrode (signal impression electrode) 33 corresponding to each laminating type piezoelectric device 29 (refer to drawing 12 (b)).
[0003] The end-face electrode (external electrode) which interconnected the internal electrode every other layer is prepared in the ends side of the piezoelectric devices 29 and 30 of each piezoelectric-device train 31. The external electrode of one end face is connected to the individual electrode 33 which is an internal electrode on a substrate 14 about an other-end side electrode through a conductive material at the common electrode 32 which is an internal electrode on a substrate 14, respectively. Furthermore, the supporter material 34 to which upper surface height becomes almost the same as that of piezoelectric devices 29 and 30 is joined to the circumference of the piezoelectric devices 29 and 30 on a substrate 14. The laminating type piezoelectric devices 29 and 30 have a displacement output screen in the upper-limit side of a substrate and an opposite side, and output the variation rate of the same direction as the direction of a laminating by the piezo-electric longitudinal effect.
[0004]
[Problem(s) to be Solved by the Invention] by the way, with the conventional technology, in order [which processes into a piezoelectric-device plate the slit of the direction which intersects perpendicularly with a longitudinal direction] to form two or more piezoelectric devices of a book especially more, the flat-surface configuration of each piezoelectric device is a rectangle, and serves as arrangement with the same said of the nozzle the ink room allotted up corresponding to it, and for ink regurgitation Moreover, since the piezoelectric device is made to drive using the piezo-electric longitudinal effect, the distance which connects the end-face electrode and electrode pattern of a piezoelectric-device plate by conductive material is needed. Furthermore, an individual electrode is formed in the both ends of the direction which intersects perpendicularly with the piezoelectric-device plate longitudinal direction on a substrate as an electrode pattern corresponding to each piezoelectric-device train. For this reason, if a piezoelectric-device train is put in another way exceeding two trains on one actuator unit, it is difficult to prepare more mostly than two trains, therefore the number of nozzles per unit area could not be raised, but, moreover, there was the 1st problem of a low in productivity. Moreover, since the quality of the materials of a substrate and a piezoelectric device differed, when

processing a slit, there was the 2nd problem which the difference of a mutual coefficient of thermal expansion or processability produces. Furthermore, the distance which pastes all up in case a piezoelectric-device plate and supporter material are joined to a substrate was required, and when having pasted up a piezoelectric-device plate and alignment was carried out to the electrode pattern on a substrate, there was also the 3rd problem that the relative position between each piezoelectric-device plate shifted. It is offering the compact electrostrictive actuator formed by high position precision and high accumulation density by the manufacturing process by which, as for the purpose of this invention, the piezoelectric device's was simplified in the light of the above situations, and its manufacture method.
[0005]
[Means for Solving the Problem] this invention person -- the result of wholeheartedly examination -- a variation rate -- the electrostrictive actuator which an output screen displaces using the piezo-electric transversal effect -- thinking -- a piezoelectric device -- in-every-direction both directions -- abbreviation -- it is the regular intervals thing done for plane configuration in a grid pattern or alternately, and finds out that a piezoelectric device can be arranged to high accumulation, and this invention person came to complete this invention
[0006] In order to attain the above-mentioned purpose, the electrostrictive actuator of the 1st invention concerning this invention It has two or more drive pillars which are arranged at each partition classified by the grid-like slot, respectively, and function as a piezo-electric formula drive. A drive pillar consists of laminating electrode structure of the common electrode layer by which the laminating was carried out crosswise [of a slot] by turns through the piezoelectric-material green sheet, and a signal impression electrode layer, and it is characterized by having the displacement output screen which carries out a displacement output to the exterior of the drive pillar height direction by the piezo-electric transversal effect in a drive pillar upper-limit side. Two or more drive pillars can be expanded and contracted in the direction of the depth of flute by the piezo-electric transversal effect. Moreover, a drive pillar serves as an electrostrictive actuator from this material, and is formed in one.
[0007] Moreover, the electrostrictive actuator of the 2nd invention concerning this invention It is arranged alternately at each partition classified by the slot of the shape of an abbreviation grid which crosses mutually at an angle of within the limits of 45 degrees or more 90 degrees or less, respectively. It has two or more drive pillars which function as a piezo-electric formula drive. and a drive pillar It consists of laminating electrode structure of the common electrode layer by which the laminating was carried out crosswise [of a slot] by turns through the piezoelectric-material green sheet, and a signal impression electrode layer, and is characterized by having the displacement output screen which carries out a displacement output to the exterior of the drive pillar height direction by the piezo electric transversal effect in a drive pillar upper-limit side.
[0008] In the 1st and the 2nd invention, suitably, it connected with the common electrode and the signal impression electrode inside the electrostrictive actuator, respectively, and has the electrode takeoff connection which has the edge exposed to the rear face which counters the displacement output screen of a drive pillar, respectively. Thereby, it becomes possible to carry out electrical connection of the external power to a common electrode and a signal impression electrode easily. For example, the common electrode and signal impression electrode which are an internal electrode usually consist of a drive pillar section which constitutes a drive pillar, and an electrode takeoff connection which connects with a drive pillar section and arrives even at a rear face, and the configuration of a common electrode and a signal impression electrode is the same configuration, and is arranged about the direction of a laminating in the same position, and by the electrode takeoff connection, it is arranged at a drive pillar section so that it may not lap mutually about the direction of a laminating. Therefore, for every drive pillar, the edge of the electrode takeoff connection of a common electrode and the electrode takeoff connection of a signal impression electrode is arranged at the rear face, respectively, and is exposed at it, and electrical connection can be easily carried out to an external power. Moreover, in applying electrode paste on the surface of a green sheet, and forming an internal electrode, you may form beforehand so that it may fit in the interior of the field where a drive pillar section serves as a drive pillar. And in case a drive pillar is formed, the electrostrictive actuator excellent in endurance is manufactured by processing a grid-like slot so that an internal electrode may be settled in a drive pillar.
[0009] Moreover, the electrostrictive actuator of the 3rd invention concerning this invention It has two or more drive pillars which are arranged on a substrate through a slot and function as a piezo-electric formula drive, respectively. A drive pillar consists of laminating electrode structure of the common electrode layer by which the laminating was carried out by turns in the direction of the depth of flute through the piezoelectric-material green sheet, and a signal impression electrode layer, and it is characterized by having the displacement output screen which carries out a displacement output outside by the piezo-electric longitudinal effect in the drive pillar upper-limit side of a substrate from an opposite side.
[0010] In the 1st to 3rd invention, you may have a drive pillar and a dummy pillar in outline same height in drive

columniation. when not making the drive pillar of the next door of a drive pillar (henceforth a drive drive pillar) which is made to drive a drive pillar individually and drives it by this drive, the drive pillar which is not made to drive faces -- large -- it can suppress -- the output of a drive drive pillar -- a variation rate can be used effectively Moreover, in the 1st to 3rd invention, a common electrode and a signal impression electrode may be built in in a drive pillar, and the front face may be worn by piezoelectric-material green-sheet material. The electrostrictive actuator of the 1st to 3rd invention is mainly an electrostrictive actuator for ink-jet heads, and each drive pillar functions as a drive into which ink is made to flow out of the ink nozzle of an ink-jet head. Thereby, the printable electrostrictive actuator for ink-jet recording devices is realizable with high density.

[0011] The manufacture method of the electrostrictive actuator concerning this invention method It is the manufacture method of the electrostrictive actuator the 1st invention, and the electrode paste of a predetermined configuration is applied to the predetermined position of one field of a piezoelectric-material green sheet, and a common electrode or a signal impression electrode is formed. subsequently Come by turns to carry out two or more sheet laminating of the piezoelectric-material green sheet which has the piezoelectric-material green sheet which has a common electrode, and a signal impression electrode. With the process which forms the laminating electrode soma material which has an internal electrode, and the process which forms the laminating electrode soma material which does not have the internal electrode which comes to carry out two or more sheet laminating of the piezoelectric-material green sheet, subsequently With the process which carries out the laminating of the laminating electrode soma material which has an internal electrode, and the laminating electrode soma material which does not have an internal electrode by turns, pressurizes it, sinters further, and forms a laminating electrode object, subsequently the variation rate which intersects perpendicularly with a sheet side -- an output-screen side -- processing it -- a variation rate -- the process which forms the field which has an output screen -- further -- a variation rate -- it is characterized by having the process which forms a grid-like slot in the field which has an output screen, and forms the drive pillar by which plane configuration was carried out to the shape of the squares of outline regular intervals

[0012] A press etc. performs pressurization. As sintering, it calcinates, for example. When a piezoelectric-material green sheet contains a binder in that case, a ** binder process is performed. Moreover, grinding usually performs processing. Since a slot is a grid-like, it is formed in pitches, such as an outline. By formation of a slot, the drive pillar of the high accumulation density by which plane configuration was carried out in a grid pattern can be formed. By the dawn method from the ** 1st, a drive pillar serves as a substrate from this material, and is formed in one. Therefore, the process which joins a piezoelectric-device plate to a substrate becomes unnecessary, generating of the error of the relative position of a drive pillar etc. can be suppressed, and, moreover, productivity improves sharply.

[0013] Moreover, the manufacture method of the electrostrictive actuator of the dawn method from the ** 2nd concerning this invention method It is the manufacture method of the electrostrictive actuator the 2nd invention, and the electrode paste of a predetermined configuration is applied to the predetermined position of one field of a piezoelectric-material green sheet, and a common electrode or a signal impression electrode is formed. subsequently Come by turns to carry out two or more sheet laminating of the green sheet which has the green sheet which has a common electrode, and a signal impression electrode. the process which forms the laminating electrode soma material which has an internal electrode, and a piezoelectric-material green sheet -- two or more sheets -- ****** -- subsequently with the process which forms the laminating electrode soma material which does not have an internal electrode With the laminating electrode object formation process which forms the laminating electrode object which shifts in predetermined length one by one, carries out the laminating of the laminating electrode soma material which has an internal electrode, and the laminating electrode soma material which does not have an internal electrode by turns and pressurizes it, and it comes to sinter further, subsequently the variation rate which intersects perpendicularly with a sheet side -- an output-screen side -- processing it -- a variation rate -- the process which forms the field which has an output screen -- further -- a variation rate -- it is characterized by having the process which forms the slot of the shape of an abbreviation grid which has the degree of crossed axes angle corresponding to the length shifted at the laminating electrode object formation process in the field which has an output screen By the dawn method from the ** 2nd the degree of crossed axes angle of a slot is usually within the limits of 45 to 90 degrees.

[ ]

[Embodiments of the Invention] The example of an operation gestalt is given to below, and the gestalt of operation of this invention is explained to it with reference to an accompanying drawing at concrete and a twist detail.

[Example] example of the one example operation gestalt of an operation gestalt is an example of an operation gestalt of the 1st invention. (c) is the perspective diagram of the electrostrictive actuator of this example of an operation gestalt, a plan and rear view from drawing 1 (a), respectively.

[0015] The electrostrictive actuator 1 of this example of an operation gestalt is equipped with two or more drive pillars

uich are arranged at each partition classified by the grid-like slot, respectively, and function as a piezo-electric ...ula drive. The plan showing the pattern of the common electrode whose drawing 2 is the internal electrode which ...ied on it with the piezoelectric-material green sheet, and drawing 3 are the plans showing the pattern of the signal ...ession electrode which are a piezoelectric-material green sheet and an internal electrode applied on it. The drive ...ar 8 consists of laminating electrode structure of the common electrode 2 by which the laminating was carried out ...swise [of a slot] by turns through the piezoelectric-material green sheet, and the signal impression electrode 3, and ...s displacement output-screen (electrostrictive actuator output screen) 1a which carries out a displacement output to ...xterior of the drive pillar height direction by the piezo-electric transversal effect in a drive pillar upper-limit side. ...common electrode 2 and the signal impression electrode 3 are constituted from a drive pillar section 6 which ...itutes a drive pillar, and an electrode takeoff connection 7 which connects with the drive pillar section 6 and ...es even rear-face 1r (refer to drawing 1 (c)) of an electrostrictive actuator 1 by each. Moreover, the common ...rode 2 and the signal impression electrode 3 are formed so that it may be arranged in the position with which the ...e pillar section 6 is the same position about the direction of a laminating, and the electrode takeoff connection 7 ...s not lap mutually about the direction of a laminating, respectively. In rear-face 1r, the edge of the electrode takeoff ...nection of a common electrode and the electrode takeoff connection of a signal impression electrode arranges and is ...osed to a single tier for every drive pillar, respectively (refer to drawing 1 (c)).

[0016] In this example of an operation gestalt, although the number of the common electrodes 2 and the signal ...ession electrodes 3 which are applied to each sheet is three, respectively, according to the number of requests of ...ive pillar 8, you may make [more / still] them. Moreover, although what consists of PZT system ceramics which ...iezoelectric material as a piezoelectric-material green sheet (only henceforth a green sheet), and an organic binder ...used, you may use the common ferroelectric as a piezoelectric material etc. Moreover, although the green sheet ...manufactured using the doctor blade method and thickness was set to about 30 micrometers, it is possible to ...sider as the thickness according to the amount of displacement of a request of an electrostrictive actuator 1.

[0017] Hereafter, the manufacture method of an electrostrictive actuator is explained. First, the laminating of the sheet ...ich applied the common electrode 2, and the sheet 5 which applied the signal impression electrode 3 was carried ...y turns so that the drive pillar section 6 of each electrode pattern might lap mutually, and so that the electrode ...ff connection 7 might not lap mutually in the common electrode 2 and the signal impression electrode 3 (this thing ...carried out the laminating is hereafter called "group containing a drive pillar section"). The group containing a ...e pillar section consists of 20 layers. Moreover, two or more sheet laminating of the sheet which does not apply an ...trode was carried out separately (this thing that carried out the laminating is hereafter called "group which does not ...ain a drive pillar section"). The group which does not contain a drive pillar section also consists of 20 layers. in ...tion -- although the common electrode 2 and the signal impression electrode 3 on a green sheet were formed by ...ying a silver palladium paste (screen-stencil) -- other conductors -- you may form by vacuum evaporationo etc. ...g a metal

[0018] Subsequently, the laminating of the 1d of the groups which do not contain a drive pillar section was further ...ed out to group 1c containing a drive pillar section by turns, and layered product 1e which has 1d of two groups ...h do not contain three bodies and a drive pillar section for group 1c containing a drive pillar section was formed. ...ing 4 (a) and (b) are the perspective diagrams and plans of layered product 1e, respectively. A dashed line shows ...uter frame of the common electrode 2 built in and the signal impression electrode 3 by drawing 4 . In addition, in ...ing 4 (a), since it is easy, the dashed line is drawn only on the thing of most this side among group 1c containing a ...e pillar section. As a result of carrying out a laminating by turns, as shown in drawing 4 (a) and (b), the portion ...h forms the drive pillar 8 was arranged by three trains, respectively in the direction which intersects ...endicularly in the successive installation direction 11 of internal electrodes 2 and 3, i.e., a direction parallel to each ...n sheet, and the successive installation direction 11. In addition, it is also possible to carry out the laminating of ...u more groups according to the desired array of the drive pillar 8.

[0019] Subsequently, with a heat press etc., the above-mentioned layered product 1e was stuck by pressure, and it ...ed. Since a lot of organic binders were contained inside layered product 1e, further, ** binder distance was ...rmed, and it calcinated at 1100 degrees C continuously. Subsequently, the dicing saw cut in the desired size as a ...of an electrostrictive actuator at the layered product after baking. At that time, in consideration of positioning a ...ed product at the time of recessing for separating each drive pillar 8 and making it become independent, it was ...essed so that the edge of the common electrode 2 and the signal impression electrode 3 might be exposed to ...cement output-screen 1a. Furthermore, appearance processing which the edge of the electrode takeoff connection ...poses was performed from the rear-face side of a layered product, and the terminal which impresses voltage to each ...e pillar 8 was formed in rear-face 1r.

[0020] Then, the dicing saw performed recessing and the drive pillar 8 which has the drive pillar section 6 was formed so that it might explain below. First, two or more slots 12 which have the same width of face as 1d of groups which do not contain a drive pillar section were formed between the groups which contain a drive pillar section in the successive installation direction 11. The slot 12 was formed by putting in slitting with a depth of 1mm from the upper surface. Then, the slot 13 which has the same width of face as the interval between drive pillar sections was processed in the direction of an internal-electrode laminating which intersects perpendicularly with a slot 12, and two or more drive pillars 8 were formed in it (refer to drawing 1 (a) and (b)).

[0021] The drive pillars 8 are an electrostrictive actuator 1 and this material, and one was consisted of by the above distance, and the electrostrictive actuator by which plane configuration of the drive pillar 8 was carried out to the shape of a matrix was manufactured. In addition, although each of each drive pillar pitches of the direction where each width of face [each of] of 0.718mm and the drive pillar 8 in every direction is 0.3mm, and the successive installation direction 11 of internal electrodes 2 and 3 and it, and the width of face of slots 12 and 13 cross at right angles is 1.018mm, these values can be changed according to the request pitch of a drive pillar etc.

[0022] Subsequently, external electrode connection for applying applied voltage to each drive pillar 8 was made as follows. In rear-face 1r, the takeoff-connection cross section 15 of the common electrode 2 and the takeoff-connection cross section 16 of the signal impression electrode 3 corresponding to each drive pillar 8 were exposed, respectively, applied the silver paste (not shown) to these, and formed the external electrode. Furthermore, the FPC cable (not shown) which has the possible pattern of carrying out voltage impression alternatively between the common electrode 2 of each drive pillar 8 and the signal impression electrode 3 was connected to the external electrode. Consequently, each drive pillar 8 can be driven individually. in addition, the method of the above [an external electrode] -- replacing with -- a conductor -- metaled vacuum evaporationo and a conductor -- you may form by performing printing of a paste etc.

[0023] Hereafter, operation of the electrostrictive actuator 1 manufactured in this example of an operation gestalt is explained. Voltage is impressed through the FPC cable linked to rear-face 1r between the common electrode 2 of each drive pillar 8, and the signal impression electrode 3. Thereby, the potential difference arises through the electrode takeoff connection 7 between the drive pillar section 6 of the common electrode 2, and the drive pillar section 6 of the signal impression electrode 3, and the variation rate of a perpendicular direction 10 is outputted to displacement output-screen 1a by the piezo-electric transversal effect.

[0024] In addition, an electrostrictive actuator 1 replaces with the common electrode 2 and the signal impression electrode 3. It has the common electrode and signal impression electrode by which the laminating was carried out by turns in the direction of the depth of flute through the piezoelectric-material green sheet. Even if it is the structure of having the displacement output screen (electrostrictive actuator output screen) which carries out a displacement output to the exterior of the drive pillar height direction by the piezo-electric longitudinal effect in a drive pillar upper-limit side, like this example of an operation gestalt, it is compact and it is possible to carry out a variation rate for every drive pillar.

[0025] As a result of impressing the voltage of a wave as shown in the FPC cable connected to the example of experiment 1 electrostrictive actuator 1 which performed the check of an electrostrictive actuator of operation at drawing 10 , the variation rate of about a maximum of 0.3 micrometers has been outputted. the result which conducted the same drive experiment also to other drive pillars -- an output equivalent with all drive pillars -- a variation rate -- the property was acquired Furthermore, as shown in drawing 11 , it attached by including an electrostrictive actuator 1 in the ink-jet head which has a nozzle 21, the pressure room 22, the ink passage 23, and a diaphragm 24. Subsequently, as a result of impressing the voltage of the wave shown in drawing 10 and performing the regurgitation evaluation examination of an ink drop, it checked that the regurgitation of the ink drop could be stably carried out from all the nozzles 21.

[0026] The example of the two example operation gestalt of an operation gestalt is an example of an operation gestalt of the electrostrictive actuator of the 2nd invention, and its manufacture method. Drawing 5 is the plan of the electrostrictive actuator of this example of an operation gestalt. The electrostrictive actuator 40 of this example of an operation gestalt is the same composition as an electrostrictive actuator 1 except for plane configuration of the drive pillar being alternately carried out to the shape of a matrix which intersects perpendicularly in all directions compared with the electrostrictive actuator 1 of the example 1 of an operation gestalt by which plane configuration is carried out. A drive pillar 42 of an electrostrictive actuator 40 is arranged alternately at each partition classified by the slot of the shape of an abbreviation grid which crosses mutually with the degree of crossed axes angle of theta= 85 degrees, respectively, and functions as a piezo-electric formula drive.

[0027] In order to have manufactured the electrostrictive actuator 40 in this example of an operation gestalt, when carrying out the laminating of the group containing a drive pillar section, and the group which does not contain a drive

pillar section by turns compared with the example 1 of an operation gestalt using the sheet 4 and sheet 5 which were used in the example 1 of an operation gestalt, group 1c containing a drive pillar section carried out and changed the laminating into the state where only the same predetermined length moved in the successive installation direction 11 one by one. Predetermined length is the length corresponding to the degree theta of crossed axes angle. Then, ** binder distance, baking, and appearance processing were performed like the example 1 of an operation gestalt.

[0028] Then, the dicing saw performed recessing explained below and the drive pillar 42 containing the drive pillar section 6 of the internal electrode (the common electrode 2 and signal impression electrode 3) exposed to the upper surface was formed. First, the slot 12 was formed like the example 1 of an operation gestalt. Subsequently, the slot 12 and the slot 43 which crosses at 85 degrees were formed. The drive pillars 42 were an electrostrictive actuator 40 and one, and same material was consisted of by the above distance and the electrostrictive actuator 40 by which plane configuration was moreover carried out alternately was manufactured.

[0029] As a result of conducting the same drive experiment as the example 1 of example of experiment 2 experiment which performed the check of an electrostrictive actuator of operation, it checked outputting the variation rate all whose drive pillars are about 0.3 micrometers. Furthermore, when it included in the ink-jet head which showed the actuator manufactured in this example of an operation form to drawing 11 and the **** evaluation examination was performed, the ink drop has been stabilized and ****(ed) from all the nozzles 21.

[0030] The example of the three example operation gestalt of an operation gestalt is an example of an operation gestalt of the electrostrictive actuator which can perform electrical connection to the internal electrode of an external power not by rear-face 1r of an actuator output screen but by displacement output-screen 1a, and its manufacture method. Each of drawing 6 (a) and (b) is the side cross sections showing the internal-electrode pattern of the electrostrictive actuator 44 of this example of an operation gestalt, drawing 6 (a) shows a common electrode pattern, and drawing 6 (b) shows a signal impression electrode pattern. The electrostrictive actuator 44 is equipped with the drive pillar 48. The drive pillar 48 is formed in the same position with the same composition as the drive pillar 8 except for the edge of the common electrode 2 and the signal impression electrode 3 being exposed to side 46a which counter mutually, and b, respectively.

[0031] In order to have manufactured the electrostrictive actuator 44, it formed by applying the common electrode and signal impression electrode which are the example 1 of an operation gestalt, or 2, and have drive pillar section 47a and , respectively instead of applying the common electrode 2 and the signal impression electrode 3 on a green sheet (screen-stencil). Then, the drive pillar 48 which exposed the edge of drive pillar section 47a of a common electrode and drive pillar section 47b of a signal impression electrode, respectively was formed in side 46a which counter mutually, and b, respectively by forming a layered product and performing appearance processing and recessing like the example 1 of an operation gestalt, or 2. Furthermore, the electric wiring which applies a silver paste (not shown) to side 46a and bes an external electrode on the whole surface, then impresses voltage from an external power was connected to this external electrode.

[0032] Since the electrostrictive actuator 44 of this example of an operation gestalt does not need to form the electrode takeoff connection 7 connected to rear-face 1r of an actuator output screen from the drive pillar section 6 like the examples 1 and 2 of an operation gestalt, the amount of internal-electrode material or the piezoelectric material used can be reduced, and the low electrostrictive actuator of a manufacturing cost is realized.

[0033] Example of operation gestalt 4 drawing 7 is the perspective diagram of the electrostrictive actuator of this example of an operation gestalt. The electrostrictive actuator 50 of this example of an operation gestalt has the support pillar 52 which consists only of a piezoelectric-material green sheet in which are a drive pillar and an outline same size and the laminating was carried out to drive intercolumniation by grid-like recessing compared with the electrostrictive actuator of the example 1 of an operation gestalt by which only a drive pillar is formed in the layered product upper part as a dummy pillar. The support pillar 52 does not have the common electrode 2 and the signal impression electrode 3 which are an internal electrode, but consists of only piezoelectric-material green sheets by which the laminating was carried out.

[0034] The manufacture method of an electrostrictive actuator 50 is explained below. In this example of an operation gestalt, layered product 1e was first formed like the example 1 of an operation gestalt. Subsequently, it was the slot which forms the drive pillar 8 and the support pillar 52, and it was parallel to the successive installation direction 11, and the slot 56 formed between 1d of groups which do not contain group 1c containing a drive pillar section and a drive pillar section was processed. Then, the slot 58 was processed between the drive pillar 8 and the support pillar 52 towards intersecting perpendicularly with a slot 56. Although width of face of the drive pillar 8 and the support pillar 52 was set to 1.018mm in this example of an operation gestalt, respectively in 0.3mm and the direction which intersects perpendicularly the pitch of 0.209mm and the drive pillar 8 in the successive installation direction 11 and the

successive installation direction of an internal electrode in the width of face of slots 56 and 58, these values can be changed according to the request pitch of a drive pillar etc.

[0035] The electrostrictive actuator 50 manufactured by the example of the three example operation gestalt of an experiment which performed the check of an electrostrictive actuator of operation was applied as an ink-jet head like the example 1 of an experiment, and the experiment which compares about the regurgitation of the ink drop in the case where there is nothing with the case where there is a support pillar 52 was conducted. consequently, deformation of other parts suppresses by having had the support pillar 52 further -- having -- the output of the drive pillar 8 -- the variation rate could be used effectively and the degree of a cross talk phenomenon has been reduced namely, the output which the regurgitation takes -- it was checked that can mitigate a variation rate and dispersion in the regurgitation property of each nozzle mitigates

[0036] The example of the five example operation gestalt of an operation gestalt is an example of an operation gestalt of the electrostrictive actuator of the structure which the drive pillar section of an internal electrode does not expose compared with the example 1 of an operation gestalt. Each of drawing 8 (a) and (b) is the side cross sections showing the internal-electrode pattern of the electrostrictive actuator 60 of this example of an operation gestalt, drawing 8 (a) shows a common electrode pattern, and drawing 8 (b) shows a signal impression electrode pattern. The electrostrictive actuator 60 is the same as the electrostrictive actuator 1 of the example 1 of an operation gestalt except for the common electrode and signal impression electrode which are an internal electrode being built in the drive pillar 62 of an electrostrictive actuator 60, and the front face being worn by piezoelectric-material green-sheet material.

[0037] In order to manufacture an electrostrictive actuator 60, in case a slot is processed, except for processing it so that the edge of the drive pillar section 66 of an internal electrode may not be exposed to the outside of the drive pillar 62, it is the same as the example 1 of an operation gestalt.

[0038] In this example of an operation gestalt, since the drive pillar section 66 is formed so that it may fit in the interior of the drive pillar 62, and an internal electrode is not exposed to the outside of the drive pillar 62 at the process which applies an internal electrode on a green sheet, there is an effect which can suppress the short circuit between each electrode layer.

[0039] The experiment which compares the endurance ability when not exposing with the case where the drive pillar section 66 of an internal electrode is exposed, using the example electrostrictive actuator 60 of an experiment which performed the performance check of an electrostrictive actuator was conducted. Consequently, it was checked by not exposing the drive pillar section 66 that endurance can be improved.

[0040] Although the depth of flute of the shape of the shape of a grid and an abbreviation grid was processed according to the soffit of the drive pillar section 66 of an internal electrode in the example 5 of the example operation gestalt of an alteration of the example 5 of an operation gestalt as shown in drawing 8 , the 1st electrostrictive actuator (not shown) of this example of an alteration is an electrostrictive actuator which comes to form a grid-like slot rather than the soffit of the drive pillar section 66 deeply relatively. In the 1st electrostrictive actuator, the stress concentration in the groove bottom edge section circumference was eased, and the effect which can improve the endurance of an electrostrictive actuator 60 further was acquired. Moreover, the 2nd electrostrictive actuator (not shown) of this example of an alteration is an electrostrictive actuator with the soffit position of the drive pillar section 66 deeper than the bottom of a grid-like slot. the 2nd electrostrictive actuator -- the drive pillar of the same height -- comparing -- an output -- the effect which can improve a variation rate was acquired Furthermore, although the drive pillar was considered as the composition which carries out plane configuration of nine of every direction 3x3 in the example 5 of an operation gestalt, the electrostrictive actuator which has further many drive pillars 62 compared with an electrostrictive actuator 60 was able to be formed by increasing the number of electrode patterns of the sheet of one sheet, or increasing the number of laminatings of the group containing a drive pillar section, and the group which does not contain a drive pillar section according to a desired array. In addition, it checked that the same effect as this example of an alteration was acquired also in the examples 1-4 of an operation gestalt.

[0041] Each of example of operation gestalt 6 drawing 9 (a) and (b) is the side cross sections showing the internal-electrode pattern of the electrostrictive actuator of this example of an operation gestalt, drawing 9 (a) shows a common electrode pattern, and drawing 9 (b) shows a signal impression electrode pattern. The electrostrictive actuator 70 of this example of an operation gestalt is the same composition as the electrostrictive actuator 60 of the example 5 of an operation gestalt except for an internal electrode replacing electrode takeoff-connection 76a and b with the electrode takeoff connection 7, and having them. Electrode takeoff-connection 76a and b have exposed the edge to side 74a and b with the drive pillar 72 of an electrostrictive actuator 70 counters. In this example of an operation gestalt, after manufacturing an electrostrictive actuator 70, side 74a, external electrode 78a which come to apply a silver paste to the internal-electrode edge exposed to b, and b were formed. By this example of an operation gestalt, the same effect as the

mple 5 of an operation gestalt was able to be done so.

2]

ect of the Invention] As explained above, according to the electrostrictive actuator concerning the 1st invention of this invention, it has two or more drive pillars which are arranged at each partition classified by the grid-like slot, respectively, and function as a piezo-electric formula drive, and a displacement output is carried out to the exterior of the drive pillar height direction by the piezo-electric transversal effect. Thereby, since it is the same quality of the material as an electrostrictive actuator and two or more drive pillars can be prepared in an electrostrictive actuator and one, it becomes reducible [the improvement in the position precision of a drive pillar, and a manufacturing process]. Moreover, since the electric end-connection section of the internal electrode which the plane configuration of the drive pillar can be carried out in the shape of a matrix, and constitutes a drive pillar can be performed with the actuator rear face, the compact electrostrictive actuator by which the drive pillar has been arranged by high accumulation density is realized. An effect with the same said also of the 2nd and the 3rd invention can be done so. The dummy pillar which consists only of a piezoelectric-material green sheet by which are a drive pillar and outline same height and the laminating was suitably carried out to drive intercolumniation is prepared. Thereby, a cross talk phenomenon can be prevented.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (c) is the perspective diagram of the electrostrictive actuator of the example 1 of an operation gestalt, a plan, and rear view from drawing 1 (a), respectively.
[Drawing 2] It is the plan showing the pattern of the common electrode which are a piezoelectric-material green sheet and an internal electrode applied on it.
[Drawing 3] It is the plan showing the pattern of the signal impression electrode which are a piezoelectric-material green sheet and an internal electrode applied on it.
[Drawing 4] Drawing 4 (a) and (b) are the perspective diagrams and plans of a layered product which are formed in the example 1 of an operation form, respectively.
[Drawing 5] It is the plan of the electrostrictive actuator of the example 2 of an operation form.
[Drawing 6] Drawing 6 (a) and (b) are the side cross sections showing the drive pillar section pattern of the internal electrode of the electrostrictive actuator of the example 3 of an operation form, drawing 6 (a) shows a common electrode and drawing 6 (b) shows the drive pillar section of a signal impression electrode.
[Drawing 7] It is the perspective diagram of the electrostrictive actuator of the example 4 of an operation gestalt.
[Drawing 8] Each of drawing 8 (a) and (b) is the side cross sections showing the internal-electrode pattern of the electrostrictive actuator of the example 5 of an operation gestalt, drawing 8 (a) shows a common electrode pattern, and drawing 8 (b) shows a signal impression electrode pattern.
[Drawing 9] Each of drawing 9 (a) and (b) is the side cross sections showing the internal-electrode pattern of the electrostrictive actuator of the example 6 of an operation gestalt, drawing 9 (a) shows a common electrode pattern, and drawing 9 (b) shows a signal impression electrode pattern.
[Drawing 10] It is the examples 1-6 of an operation form, and is the wave of the voltage which carries out a seal of level between a common electrode and signal applied voltage.
[Drawing 11] It is the side cross section showing the state where the electrostrictive actuator of the example 1 of an operation form was included in the ink-jet head.
[Drawing 12] Drawing 12 (a) and (b) are the perspective diagrams for every process which manufactures the conventional electrostrictive actuator, respectively.
[Description of Notations]
1 Electrostrictive Actuator
1 Displacement output screen
The group containing a drive pillar section
The group which does not contain a drive pillar section
Layered product
Surface
Common Electrode
Signal Impression Electrode
Green Sheet Which Applied Common Electrode (Sheet)
Green Sheet Which Applied Signal Impression Electrode (Sheet)
Drive Pillar Section
Electrode Takeoff Connection
Active Pillar
Perpendicular Direction
Successive Installation Direction

'ot
:t
bstrate
keoff-Connection Cross Section of Common Electrode
eoff-Connection Cross Section of Signal Impression Electrode
zzle
essure Room
Passage
iaphragm
attern for Electrodes
ttern for Electrodes
zoelectric-Device Plate
chanical-Component Piezoelectric Device
d Part Piezoelectric Device
oelectric-Device Train
mmon Electrode
vidual Electrode
porter Material
ectrostrictive Actuator
ctrostrictive Actuator
ive Pillar
trostrictive Actuator
Side
Drive pillar section
e Pillar
ctrostrictive Actuator
port Pillar
t
t
ctrostrictive Actuator
e Pillar
ve Pillar Section
ctrostrictive Actuator
e Pillar
Side
Electrode takeoff connection
External electrode

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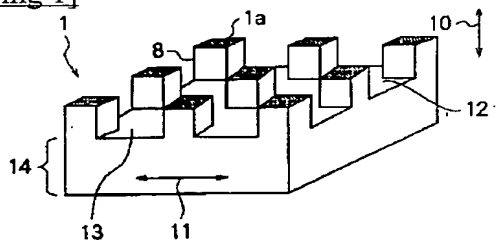
tion done.]

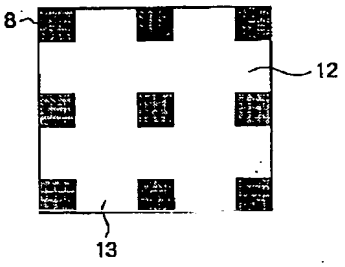
* OTICES *

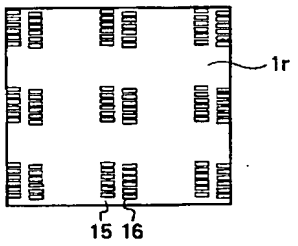
1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]







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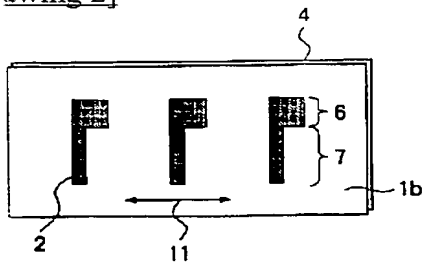

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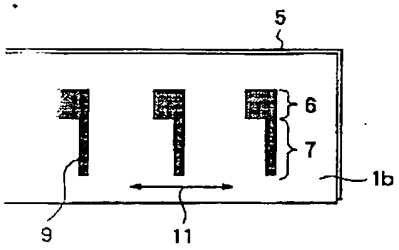
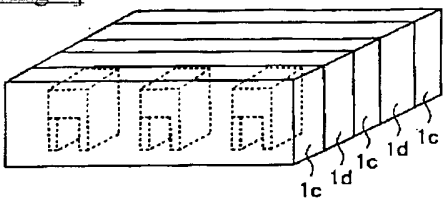


[Drawing 4]

a)



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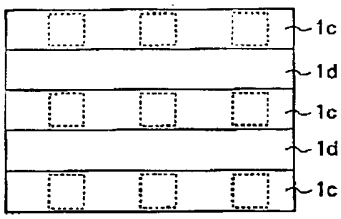

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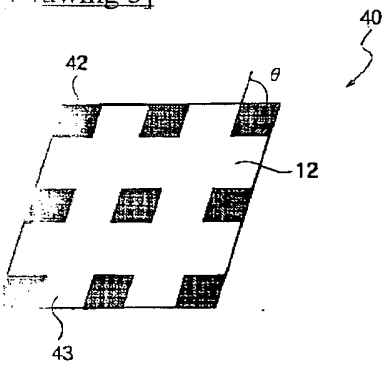

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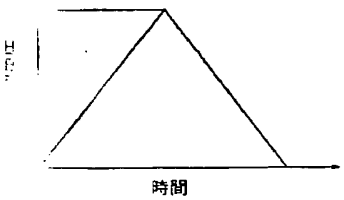

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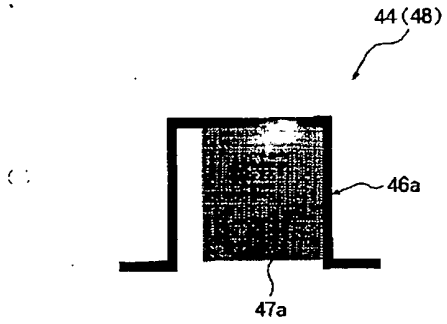

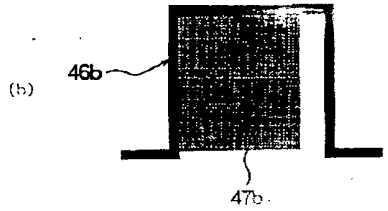

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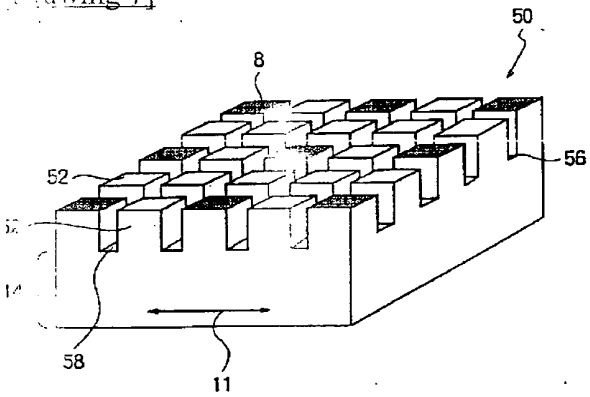

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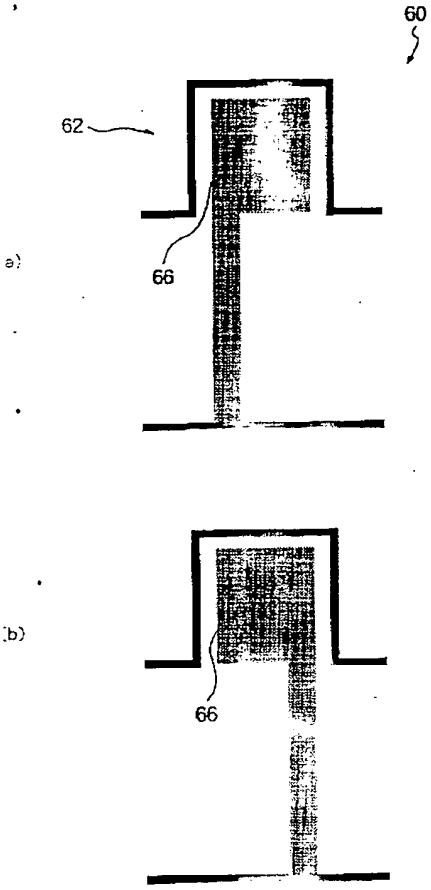

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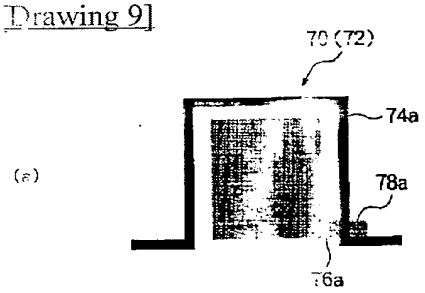
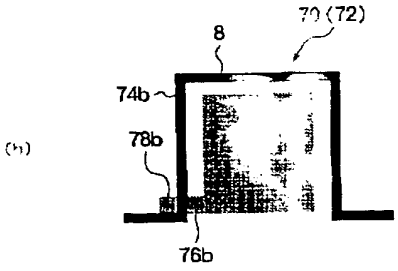
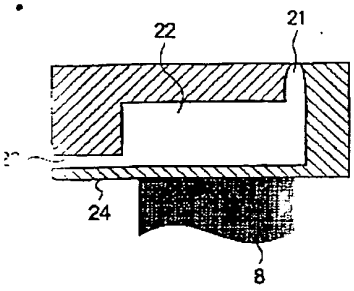




Drawing 11]



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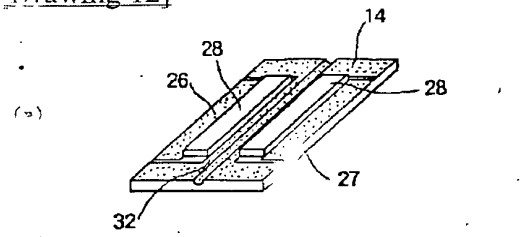

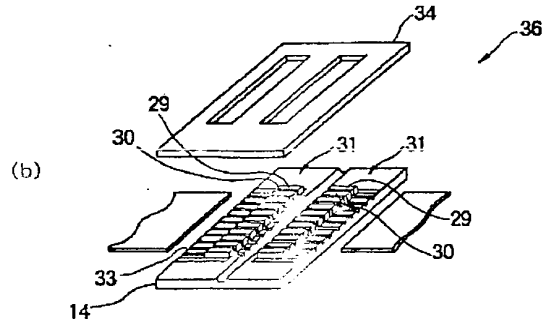

[Translation done.]